BIOMEDICAL ENGINEERING, PH.D.

The biomedical engineering Ph.D. program at Saint Louis University will strongly focus on independent research and innovation, pursuit of academic excellence, strong industry partnerships, innovative teaching methodologies, and diversity and inclusion. These elements will collectively prepare students for successful careers and address the evolving needs of the region, nation and world.

As part of their degrees, the students will take graduate-level courses at SLU to deepen their knowledge, understanding and skills in the discipline as well as perform independent discovery or design-focused original research under the guidance of a graduate faculty member. The degree will culminate in the defense of a dissertation as well as original research publications in peer-reviewed journals and research presentations at local and national scientific conferences. This high level of scholarship will increase the department's visibility and reputation among peer institutions and will position our graduates to become leaders in their chosen fields.

Curriculum Overview

This is a 42-credit-hour program, with 30 hours of coursework and 12 hours of dissertation research. Full-time students typically complete their coursework in two and a half years. Students choose between a written or an oral qualifying exam, which they will take by the end of their second year. They will have an oral defense of their dissertation proposal at the end of their coursework.

Fieldwork and Research Opportunities

School of Science and Engineering graduate students gain valuable experience working with both faculty and peers. Additional opportunities to publish in scientific journals and attend professional conferences prepare our graduates for careers in industry or academia.

Saint Louis University's location in a vibrant and industry-rich city means that faculty members have access to and relationships with industry professionals. The School of Science and Engineering provides many opportunities for these professionals to interact with students, share their real-world experiences, network and even collaborate on research projects. Therefore, students have access not only to top-notch faculty but to the most recent developments in industry.

The expert faculty of the School of Science and Engineering collaborate with graduate students in groundbreaking research in the following areas:

- Biomaterials
- Human movement
- Drug delivery
- Engineering education
- Haptic and human-machine interfaces
- Innovation and entrepreneurship
- Biomechanics
- Mechanotransduction
- Neuroengineering
- Tissue engineering and regenerative medicine

Careers

Doctoral program graduates seek employment in the industry, government or in an academic setting.

Admission Requirements

Apply Here (https://www.slu.edu/apply.php)

Most admitted students meet the following criteria:

- Undergraduate cumulative GPA of at least 3.00
- A four-year undergraduate degree in Biomedical Engineering, Bioengineering, Biochemical/Biomolecular/Bioelectrical Engineering or closely related engineering and science discipline
- Additional consideration will be prior research experience demonstrated by the applicant, which could be in the form of an earned thesis MS degree from a previous institution or an undergraduate research experience with a demonstrated research output (e.g., conference presentations, publications, etc.). Such students will be given higher consideration for acceptance into the program even though students coming directly from a BS degree with no prior research experience will also be considered if they clearly demonstrate an ability and motivation to conduct independent scientific research.
- Acceptance decisions will be based on BME faculty expertise and lab openings such that incoming students can be successfully matched with a faculty member to conduct a research project that is in alignment with the student's preparation, interest, and career goals.

Application Requirements

- Application form
- Transcript(s) from all colleges and universities attended
- Three letters of recommendation (preferably from recent instructors or research advisors)
- Résumé or curriculum vitae
- Professional goal statement

Requirements for International Students

Along with the general admission requirements above, the following must be provided by prospective international students:

- Demonstration of English Language Proficiency (https://catalog.slu.edu/academic-policies/office-admission/graduate/english-language-proficiency/).
- Proof of financial support that must include:
  - A letter of financial support from the person(s) or sponsoring agency funding the time at Saint Louis University.
  - A letter from the sponsor's bank verifying that the funds are available and will be so for the duration of study at the University.
- Academic records, in English translation, for postsecondary studies outside the United States. These must include the courses taken and/or lectures attended, practical laboratory work, the maximum and minimum grades attainable, the grades earned or the results of all end-of-term examinations, and any honors or degrees received. WES and ECE transcripts are accepted.

Review Process

Applications for the Ph.D. program will be sent to the BME Department for evaluation and an admission decision will be based on BME faculty expertise and lab openings. The goal is to ensure a successful match

with a faculty member to conduct a research project that is in alignment with the student's preparation, interest, and career goals.

In cases where students come from a non-biomedical engineering background, the applications will be sent to the BME program to review and determine fit and/or pre-requisite/concurrent classes that the applicant would need to take to qualify for doctoral studies in BME. The students will receive conditional acceptance and the classes they need to take will be specified in SLATE and in the offer letter.

Tuition

Tuition	Cost Per Credit
Graduate Tuition	$1,400

Additional charges may apply. Other resources are listed below:

Net Price Calculator (https://www.slu.edu/financial-aid/tuition-and-costs/calculator.php)

Information on Tuition and Fees (https://catalog.slu.edu/academic-policies/student-financial-services/tuition/)

Miscellaneous Fees (https://catalog.slu.edu/academic-policies/student-financial-services/fees/)

Information on Summer Tuition (https://catalog.slu.edu/academic-policies/student-financial-services/tuition-summer/)

Financial Support

The School of Science and Engineering offers graduate fellowship awards and assistantships each year. Assistantships provide tuition, stipend and health insurance. There are also many opportunities for students to receive funding through external research grants that are managed by individual faculty.

For more information, visit the Office of Student Financial Services (https://slu.edu/financial-aid/).

Learning Outcomes

1. Graduates will demonstrate in-depth knowledge of theories and methodologies, to address fundamental questions in their primary field of study.
2. Graduates will engage in meaningful research within the field or explore interdisciplinary or innovative projects. Under the mentorship of an advisor, students will both design and execute research projects while developing intellectual independence; creatively synthesize broad areas of theory and scholarship to generate novel concepts and insights; demonstrate the capability to critically assess scholarly works within the discipline.
3. Follow the principles of ethics in their field and academia. Demonstrate, through independent research and service, the value of their discipline to the academy and community at large. Interact productively with people from diverse backgrounds as both leaders/mentors and team members with integrity and professionalism.
4. Students will demonstrate skills in oral and written communication, enabling them to disseminate their work effectively in their field. Students will produce original scholarly contributions in their field.
5. Students will attend and/or present their independent research to local, regional, national, or international audiences through presentations given in a range of venues, from graduate seminars to professional meetings and/or conferences/symposia/workshops; participate in professional organizations; engage in professional activities such as teaching, internships, fellowships, grant applications.

Requirements

Code	Title	Credits
Required Courses		**3**
BME 5010	Research Analysis	
BME 5040	Technical Communication in the Discipline	
Foundational Courses		**6**
Students select 6 credits from the following:		
BME 5130	Medical Imaging	
BME 5360	Reaction Kinetics and Bioreactors for Biomedical Engineering	
BME 5410	Tissue Engineering	
BME 5600	Quantitative Physiology I	
BME 5650	Quantitative Physiology II	
BME 5400	Tissue-Material Interfaces	
BME 5210	Human Movement Biomechanics	
Electives		**21**
Select 21 credits of courses with the Biomedical Engineering Graduate Elective attribute or additional courses from the Foundational Courses. *(p. 3)*		
Dissertation Research		**12**
Students will take a total of 12 credits over multiple semesters		
BME 6990	Dissertation Research	
Total Credits		**42**

Continuation Standards

Students must maintain a cumulative grade point average (GPA) of 3.00 in all graduate/professional courses.

A grade of C or lower for any class will require the student to retake the class and earn a grade of B or higher or take an equivalent class in its place, where the substitute class needs to be approved by the Graduate Program Coordinator. A student with a GPA below 3.0 or a grade of C in any class (even when the overall GPA is above 3.0) will be placed on academic probation. Students will be allowed 9 credit hours or 2 successive academic terms during which coursework registrations are recorded to return to good standing. Students will not be eligible to graduate or advance to candidacy while on academic probation.

Non-Course Requirements

Required Biomedical Engineering Seminar

The Biomedical Engineering Department offers a Graduate/Research seminar each fall and spring semester, which meets most weeks on Wednesdays at 3:30 PM. Graduate students are required to attend this seminar for the first 3 years (6 semesters) of their PhD program and encouraged to attend for the remainder of their time in the program. Students are permitted to miss at most two seminar sessions each semester during the first 2 year in the program.

Program of Study Form

By the end of their first semester, each student should complete a Program of Study form listing the courses they plan to take to complete the requirements for their program. The form needs to be filed with the SSE Graduate Office and can be updated annually as needed.

The Qualifying Examination

The qualifying examination is intended to test the student's fundamental knowledge in biomedical engineering and may be taken no more than twice. If a student is not able to pass this examination after exhausting all of the allowed chances, they could be transferred to the MS degree program or choose to leave the graduate program.

There are both written and oral qualifying exam options as described in the BME graduate handbook. The intent of the **written examination format** is to allow doctoral students to qualify for pursuit of doctoral studies by demonstrating their PhD-level knowledge in three topics related to their research project. The intent of the **oral examination format** is to allow a doctoral student to qualify for pursuit of doctoral studies through evaluation of their research writings (a first/co-first author manuscript, which could be published, accepted, submitted or in preparation), and evaluation of their responses during a single oral exam conducted after review of the writings. To successfully qualify, students must demonstrate PhD-level knowledge in three identified topical areas and the research writings submitted by the student should represent significant potential for scholarly research at the doctoral level. Each topical area selected by the student for consideration in this examination format must be related to the content of the research writings submitted by the student.

The qualifying exam (in either written or oral format) must be completed by the end of the second year of the Ph.D. program. Both written and oral qualifiers need to be taken in a single day in either early summer (June) or winter (January). Students are responsible for scheduling their qualifying exam in consultation with their PhD advisor. In the case of failure for the first attempt, written feedback will be provided that can be used by the student as guidance in their second and last attempt at this examination.

Each student will choose 3 courses for their qualifying exam (for both written and oral format), where at least one of the selected topics must be from the list of foundational BME courses. The faculty conducting the Qualifying Exam will consist of the instructors of the selected courses. In the event that course instructors have changed, a student will have the option of nominating either the current or past course instructor to provide the examination (subject to approval by the BME Graduate Program Coordinator). Three examiners must be selected for each Qualifying exam – one per course topic. For the research writing exam format, if two courses taught by the same instructor are chosen for the exam, the instructor of those courses must nominate (subject to approval by the BME Graduate Program Coordinator) an alternate instructor to provide the exam for one of the courses. If the student's graduate advisor is not an instructor for any of the selected courses, the advisor can be present at the oral exam, but will not be an evaluator.

The Dissertation Proposal

The examining committee for the proposal examination consists of the student's Guidance Committee members. As part of the proposal, students are required to submit a written document that describes the research project. The document should be submitted 2 weeks prior to the proposal defense. The document should contain enough introductory material to inform the proposal examination committee about the underlying background of the project. The document should also contain additional logically arranged sections, such as sections on objectives, experimental and theoretical methods, results, conclusions, and timelines for finishing the dissertation.

The Dissertation Proposal will be presented orally in a seminar lasting 20 to 40 minutes. Following the seminar, the Guidance Committee conducts an oral examination of the student within the area of the proposed research. Students should take this examination after passing the oral qualifying examination and after all coursework has been completed (typically after 2.5 years in the program). If a student does not pass the proposal examination on their first attempt, a second and final attempt shall occur within one additional semester.

Students who pass the qualifying and dissertation proposal examinations become Ph.D. candidates. A student must be admitted to candidacy at least two full sequential semesters before the date on which the doctorate degree will be conferred.

Final Defense of the Ph.D. Dissertation

The dissertation defense is conducted by the student's Guidance Committee. In the event that not all of the members who served on the proposal examination are available to serve on the dissertation defense committee, substitutions may be made. However, the final makeup of the dissertation defense committee must in all cases consist of at least 3 faculty members from the BME program and at least 1 person from outside the program. The minimum members required is 5.

As part of the dissertation defense, students are required to submit a written dissertation that describes the resuts from the research project. The student should consult the Formatting Guide for Saint Louis University Graduate Education for details concerning the preparation and format of the Dissertation. The traditional dissertation format typically includes an introduction, a review of the literature, methodology, results, and discussion. In addition, the Department of Biomedical Engineering offers a "manuscript-style" format. This is similar to the non-traditional format described in the Office of Graduate Education's dissertation formatting guide. If this option is used, the student will normally use the following format: Chapter 1 - Introduction; Chapter 2 - Manuscript #1; Chapter 3 - Manuscript #2; Chapter 4 - Manuscript #3; Chapter 5 - Conclusions and Future Work. With either format, the dissertation must be formatted in accordance with the regulations of Graduate Education. Once completed, the dissertation will be approved by the research mentor and a copy given to each member of the student's Guidance Committee; the dissertation should be distributed two weeks before the public presentation (see below). The committee will evaluate the dissertation, make comments and suggest any necessary corrections or changes.

The dissertation defense will be presented orally in a public seminar lasting 30 to 45 minutes. The open forum is followed by a closed-door session, where the Guidance Committee conducts an oral examination of the student within the area of the conducted research. A 2-hour block should be reserved for the defense. The time and location of defense must be publicized two weeks in advance so that the defense can be attended by all interested persons.

The candidate may only take the final oral defense twice, and students who are not able to pass the defense in two attempts will not be awarded a doctoral degree.

Biomedical Engineering Graduate Elective attributed courses

Students are limited in how many Master's Project, Co-op, Internship, and Independent Study credits can apply towards their degree. Students should check with their advisors when registering.

Code	Title	Credits
AENG 5230	Introduction to Computational Fluid Dynamics	3
BIOL 5080	Advanced Cell Biology	3

BIOL 5430	Advanced Principles of Virology	3
BIOL 5720	Advanced Cancer Biology	3
BME 5100	BioData Processing and Machine Learning	3
BME 5150	Brain Computer Interface	3
BME 5300	Biotransport	3
BME 5320	Drug Delivery	3
BME 5420	Tissue Engineering Scaffold Fabrication Techniques	3
BME 5430	Regenerative Engineering	3
BME 5455	Biomaterials Characterization and Instrumentation	3
BME 5850	Design of Biomedical Engineering Lab Experiments	3
BME 5910	Co-op with Industry	1-6
BME 5915	Internship with Industry	1-3
BME 5930	Special Topics	1-3
BME 5960	Master's Project	1-3
BME 5970	Research Topics	1-3
BME 5980	Graduate Independent Study in Biomedical Engineering	1-3
BME 6000	Preparing Future Faculty	3
BME 6930	Special Topics	1-6
BME 6970	Advanced Research Topics in Biomedical Engineering	1-3
BME 6980	Graduate Independent Study in Biomedical Engineering	1-3
BST 5100	Introduction to General Linear Modeling	3
CHEM 5610	Biochemistry 1	3
CHEM 5630	Introduction to Chemical Biology and Biotechnology	3
ECE 5153	Image Processing	3
HDS 5210	Programming for Health Data Scientists	3
MENG 5820	Technology Entrepreneurship	3
PATH 5350	Intro to Microscopy Techniques	1-3
PUBH 5040	Generating Evidence from Public Health Data	3

Roadmap

Roadmaps are recommended semester-by-semester plans of study for programs and assume full-time enrollment unless otherwise noted.

Courses and milestones designated as critical (marked with !) must be completed in the semester listed to ensure a timely graduation. Transfer credit may change the roadmap.

This roadmap should not be used in the place of regular academic advising appointments. All students are encouraged to meet with their advisor/mentor each semester. Requirements, course availability and sequencing are subject to change.

Course	Title	Credits
Year One		
Fall		
BME Foundational class		3
BME Foundational or Elective class		3
BME Seminar		
	Credits	**6**
Spring		
BME Foundational or Elective class		3
BME Elective class		3
BME Seminar		
	Credits	**6**
Year Two		
Fall		
BME Electives		6
BME Seminar		
	Credits	**6**
Spring		
BME Electives		6
BME Seminar		
PhD Qualifying Exam		
	Credits	**6**
Year Three		
Fall		
BME Elective class		3
BME 5010	Research Analysis	2
BME 6990	Dissertation Research	1
	Credits	**6**
Spring		
BME 5040	Technical Communication in the Discipline	1
BME 6990	Dissertation Research	5
Doctoral Oral Examination		
	Credits	**6**
Year Four		
Fall		
BME 6990	Dissertation Research	2
	Credits	**2**
Spring		
BME 6990	Dissertation Research	2
	Credits	**2**
Year Five		
Fall		
BME 6990	Dissertation Research	1
	Credits	**1**
Spring		
BME 6990	Dissertation Research	1
Dissertation Defense		
	Credits	**1**
	Total Credits	**42**

Program Notes

Students should finish their BME foundational coursework (six credits) by the end of year one. BME Seminar (four semesters) should be finished by the end of year two. Students should expect to take their Ph.D. qualifying examination at the end of year two, after four semesters in the program.

The doctoral oral examination (dissertation proposal) should be taken at the end of year three; upon passing the doctoral oral exam, students will become Ph.D. candidates.

Contact Us

For more information about any School of Science and Engineering graduate program, email ssegrad-admissions@slu.edu.